

AD-A063 215 BATTELLE COLUMBUS LABS OHIO F/6 17/2  
KA-BAND RELIABILITY IMPROVEMENT -- INTEGRATED RELIABILITY/MAINT--ETC(U)  
SEP 78 E N WYLER, J E DRENNAN, J L EASTERDAY F33615-75-C-1208  
UNCLASSIFIED AFAL-TR-78-135-PT-2 NL

**UNCLASSIFIED**

1 OF 1  
AD  
A053215

END  
DATE  
FILMED  
3-79  
DDC



## NOTICE

When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government Procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever, and the fact that the government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data, is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

### AFAL-TR-78-135, PART II

This report has been reviewed by the Information Office (OI) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

*Herbert M. Portman*

HERBERT M. PORTMAN  
PROJECT ENGINEER  
AFAL/AAD

*Charles C. Gaudet*

CHARLES C. GAUDET  
Chief, Avionic Communications Br  
System Avionics Division

### FOR THE COMMANDER

*Raymond S. Diford*

Raymond S. Diford, Lt Colonel, USAF  
Chief  
System Avionics Division

*Approved for Release under the  
Freedom of Information Act  
by AFAL-AAD*

*Colonel of the Air Force*

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

(19)

TR-78-135-PT-2

REPORT DOCUMENTATION PAGE			READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER 18 AFAL-TR-78-135 Part II	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle) 6 KA-BAND RELIABILITY IMPROVEMENT-- INTEGRATED [REDACTED] Reliability/Maintainability Program Plan Guide. Part II.	9	5. TYPE OF REPORT & PERIOD COVERED Final Technical Report - 15 Apr [REDACTED] -15 Jul [REDACTED] 78.	
7. AUTHOR (Name) 10 E. N. Wyler, J. E. Drennan [REDACTED] J. L. Easterday	15	8. CONTRACT OR GRANT NUMBER(s) F33615-75-C-1208	
9. PERFORMING ORGANIZATION NAME AND ADDRESS Battelle Columbus Laboratories 505 King Avenue Columbus, Ohio 43201	16	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 1227 [REDACTED] 17 01	
11. CONTROLLING OFFICE NAME AND ADDRESS Systems Avionics Division (AAD) Air Force Avionics Laboratory Wright-Patterson AFB, Ohio 45433	11	12. REPORT DATE 15 Sep [REDACTED] 78	
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) 12 19P.	13. NUMBER OF PAGES 14	15. SECURITY CLASS. (of this report) Unclassified	
16. DISTRIBUTION STATEMENT (of this Report)  Approved for public release; distribution unlimited.	15e. DECLASSIFICATION/DOWNGRADING SCHEDULE		
63431F			
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)  P 3 20 P 0 62 20			
18. SUPPLEMENTARY NOTES			
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Ka-Band SATCOM Set Availability EHF Band Dependability Reliability models Reliability Reliability Analysis Cost Estimates AABNCP			
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) Guidelines are given for preparing an integrated Reliability/Maintainability (R/M) Program Plan for use in the procurement of future generation Ka-Band SATCOM equipment. Specific attention is given to the purpose, objectives and technical content of the R/M plan. Guidelines are given for documenting the procuring agencies data requirements, evaluating the contractor's R/M program plan, establishing the R/M test program design and maintaining management visibility and control of the total R/M program.			

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

407 080 79 01 09 047

## PREFACE

This is the Final Report on studies related to Ka-Band System Reliability Improvement under Air Force Contract No. F33615-75-C-1208. The report is organized in three parts. Part I, Volume I, depicts the system model as organized in its functional relationship form; describes the overall program; presents the probabilistic estimates of reliability, maintainability, availability, dependability, etc. of the Ka-Band SATCOM Set based on all the data available; identifies the components most likely to malfunction or fail; and presents guidelines for the specification of reliability and maintainability requirements for the next generation system. Part I, Volume II, contains Appendix B which presents detailed results of the Tabular System Analysis (TASA) of the Ka-Band SATCOM Set. Part I, Volume III contains Appendix C which presents detailed results of the numerical reliability, availability and dependability predictions for the Ka-Band SATCOM Set. Part II contains guidelines for an Integrated Reliability and Maintainability (R/M) Program Plan intended as a model for the specific R/M plans that will be required for the procurement of future generation systems. Part III is the DEPEND Computer Program User's Manual. The DEPEND (Determination of Equipment Performance and Expected Nonoperational Delay) program is used to perform the arithmetic and documentation for the Tabular System Analysis.

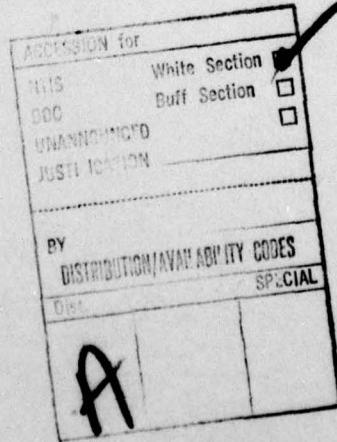


TABLE OF CONTENTS

<u>Section</u>		<u>Page</u>
I	INTRODUCTION. . . . .	1
II	RELIABILITY/MAINTAINABILITY PROGRAM PLAN. . . . .	2
	R/M PROGRAM PURPOSE. . . . .	2
	OBJECTIVES . . . . .	2
	TECHNICAL R/M PLAN . . . . .	2
	Procuring Agency R/M Information Requirements . . .	3
	Contractor R/M Program Plan . . . . .	4
	R/M Test Program Plan . . . . .	7
	R/M Management and Control. . . . .	10
III	CONCLUSIONS . . . . .	14

A0-915-582  
K-062-901  
B-032-607

## SECTION I

### INTRODUCTION

This integrated Reliability/Maintainability (R/M) Program Plan has been prepared to be used by the procuring activity in the preparation of the design specifications and the subsequent management of the R/M program for the engineering development of the dual frequency SATCOM system. This R/M program plan provides the basis for evaluation of the Engineering Development contractor's R/M program and the evaluation and monitoring of the progress of the contractor's R/M effort.

The program plan incorporates the applicable requirements of MIL-STDs 1543, 785, and 470 and draws heavily from the information contained in the "Reliability Program Management Guide", AFAL-TR-73-285. The plan covers both the USAF and Contractor responsibilities in management of the R/M program.

915 5 82

## **SECTION II**

### **RELIABILITY/MAINTAINABILITY PROGRAM PLAN**

The reliability/maintainability (R/M) plan defines the purpose and objectives of the reliability program. The plan provides identification, and scheduling, and assigns responsibility for the activities needed to meet the objectives of the program. In addition, data requirements are described and sources identified.

#### **R/M PROGRAM PURPOSE**

The purpose of the R/M program is to support the development of a reliable and maintainable dual frequency SATCOM system that will provide the U.S. Air Force with a desired command communication capability. This system shall achieve a specified mean time between failure (MTBF). The system must be survivable within a piloted aircraft under severe conditions that might be encountered in a general war, such as hostile electronic and nuclear environments.

#### **OBJECTIVES**

A series of objectives must be met to fulfill the purpose of the R/M program. These objective include:

- (1) Establish information and data requirements for the R/M program.
- (2) Establish procedures for designing reliability and maintainability into the system.
- (3) Establish procedures for assuring that high quality/reliability parts are used in the system.
- (4) Establish procedures to minimize maintenance operations.
- (5) Establish R/M analysis procedures to be used throughout the R/M program.
- (6) Develop a R/M test plan.
- (7) Develop a R/M management and control mechanism.
- (8) Define the program schedule.

#### **TECHNICAL R/M PLAN**

The responsibility for the development of the technical R/M plan for the dual-frequency SATCOM system must be shared by both the procuring agency and the contractors. The prime responsibility for formulation of the details of the

plan rests ultimately with the individual contractors with the overall plan being coordinated by the system integration contractor or U.S. Air Force Program Manager if a system contractor is not designated.

The technical R/M plan should be based upon the mission requirements of the system to be procured. The mission requirements will provide quantitative definition of the operational environment and the use reliability and maintainability requirements to be incorporated in the work statement and performance specifications for procurement. As a part of the procurement documentation the U.S. Air Force must set down the detailed performance requirements and the R/M goals for the system and set forth a listing of the information and data required from the vendor to provide a basis for a meaningful R/M test design and a measure of whether or not the goals are met. The information and data required from the vendor should provide the procuring agency a basis for evaluating the proposed R/M program of the bidding vendors and a means for predicting, accessing, and controlling the status of the R/M program as it progresses throughout the system design, development, and production phases.

#### Procuring Agency R/M Information Requirements

The work statement prepared for procurement of the dual-frequency SATCOM system must specify in some detail the requirements for data and information envisioned as necessary to the R/M program for the system design, development, and production effort. The information to be supplied by the contractor to the U.S. Air Force should include:

(1) Parts list. A complete listing of all parts to be used in the system should be supplied initially with the proposal and updated throughout the program as the development progresses. A copy of the most current listing should be included in the vendor's progress reports and should be available at all design review meetings. The parts list should be broken down by printed circuit board and chassis number according to a work breakdown structure that shows the relationship of the boards and chassis to the major assemblies and ultimately to the complete system. In addition to, or in place of this parts structure, a complete parts structure, a complete parts list must be provided organized on the basis of a system functional tree which has been prepared as the basis of the system reliability analysis.

(2) Monthly progress reports. These should be required to provide information on the status of the R/M program, updated schedules, and the latest R/M predictions. The method for predicting reliability and maintainability should utilize the TASA Dependability Model developed for the U.S. Air Force by Battelle's Columbus Laboratories. The preliminary R/M prediction may be based on parts count and generic failure rates at the smallest unit level. However, as the design, development, and production of the system progresses the R/M predictions should be made by using data from burn in and the testing program. The parts list

used for the predictions should be the most current listing specified by the vendor and should show any flag any changes from the previous list. The stress level (environmental, electrical, thermal, and mechanical) should be specified.

(3) Cost data. These are required to facilitate life cycle costs and design to cost analyses as the development program progresses. This information is required to permit reliability/maintainability/cost trade off analyses.

(4) Engineering changes. The method for handling engineering changes must be specified in the contract in a manner that provides the procuring agency with adequate information on the impact the changes will have on the system. If any change is to be made, the U.S. Air Force should receive an Engineering Change Proposal (ECP) from the vendor. This ECP should state the change proposed, the reason for the change, and an impact analyses showing the anticipated effect of the change on the reliability, maintainability, and cost of the system.

(5) Test Validation. The U.S. Air Force should require information showing validation of all tests performed by the vendor. This information should include detailed reports for each failure that occurs and the corrective action taken. The reports should show the times required for troubleshooting and actual repair of the faults.

(6) Failure Definition. The contract should provide a mechanism for defining relevant, secondary, and nonrelevant failures. This mechanism should make provision for requiring the vendor's to supply information to the U.S. Air Force as to whether or not any failure that occurs is relevant.

(7) Pattern Failures. The procurement contract should specify the method for supplying the U.S. Air Force with information on pattern failures (failures of the same part under like conditions). This information will serve to alert the Project Manager of trouble areas in the system that require definite corrective action.

#### Contractor R/M Program Plan

The U.S. Air Force RFP and contract should require that all contractors for the dual-frequency SATCOM system submit a R/M program plan. This plan should be responsive to the Air Force program purpose and information needs and cover all phases of the program from design through production. Provision should be made for submitting a preliminary reliability plan with the proposal and a final program plan early in the system development program. The Air Force should require the R/M plan to be prepared in accordance with MIL-STD-785A and MIL-STD-470. The contractor's R/M program plan should show the R/M organizational and management structure. The plan should provide a cross index showing relationships among the R/M program tasks, applicable specifications, contractor policies and standards, and other applicable reference documents. The plan also should provide information on program scheduling, review procedures, management, control, and nonloading.

### R/M Design Techniques

The contractor's R/M program plan should define design guidelines for achieving a reliable and maintainable system down to the piece-part level. Derating should be a requirement. Generally derating the dual-frequency SATCOM system should be to design for a maximum electrical stress of 0.3 (the ratio of actual power or voltage to rated power or voltage) for all except those parts which should not be derated. It is also desirable to:

- (1) Use the minimum number of parts to perform a required function.
- (2) Avoid lead-screw-activated potentiometers where possible.
- (3) Do not use unproven state-of-the-art devices.
- (4) Do not use relays unless necessary because of circuit constraints or space.
- (5) Provide for a maximum of thermal derating for all components.

All passive components should be established reliability (ER) with a failure rate level of "P" or better. Where ER components are not available, preference should be given to military standard parts over nonstandard parts. Where potentiometers are required, the RJ50 style should be used. Other passive elements such as chokes, coils, transformers, switches, etc. should be reviewed on an individual basis to establish the levels of reliability necessary to meet the design requirements.

Active components such as transistors and diodes should all be JANTX or equivalent. All integrated circuits (IC) should comply with the requirements of MIL-M-38510. When MIL-M-38510 ICs are not available the ICs used should be screened to MIL-STD-883 Class B requirements. Group C testing of MIL-STD-883 should be waived only if the vendor can show generic data collected in the last twelve months. Integrated circuits should be hermetically sealed packages. All transistors should be glass or metal can packaged. They should be selected to provide a minimum thermal resistance and a maximum operating junction temperature.

The plan should provide for incoming inspection of all parts by the contractor's quality assurance organization to assure that they comply with applicable specification requirements and this procedure should be subject to review and inspection by the USAF.

The contractor's R/M program plan should specify the general maintenance concept. This general concept should be formulated to minimize all

maintenance operations without adversely affecting reliability. The design guidelines for maintainability should include:

- (1) Minimize field adjustment and alignment requirements
- (2) Minimize maintenance skill levels and training requirements
- (3) Minimize numbers and types of facilities and support equipment
- (4) Minimize number of spares and consumable maintenance materials
- (5) Maximize accessibility to all items requiring replacement and/or repair
- (6) Design to preclude improper installation of connectors and plug-in modules
- (7) Arrange system elements functionally by subassembly so that each subassembly contains all parts necessary for a function
- (8) Arrange internal cabling in removable sections
- (9) Assure sufficient test points brought out through test connectors to permit isolation of failures to the lowest level of plug-in modules or assemblies
- (10) Design circuits to minimize the possibility of accidental grounding of test connector signals damaging LRUs.
- (11) Provide quick release fasteners on LRU access covers.

The plan should provide for incorporation and enforcement of all maintainability requirements in all subcontractor and vendor contract specifications.

#### R/M Analysis

The contractors R/M plan should define the analysis techniques and scheduling to accomplish and effective R/M analysis. The plan should provide mechanisms for trade-off analysis among reliability, maintainability, configuration, safety, human engineering, function, integrated logistic support, and cost. The R/M analysis should be made in the same manner for all system elements and for the total system. The method for the R/M analysis, especially the trade-off considerations, should include the TASA Dependability Model developed for the U.S. Air Force by Battelle's Columbus Laboratories\*. This model relates reliability and maintainability to the term dependability so that the single model can deal with both at the same time. Since this model is functional in nature, it fulfills the requirements of MIL-STD-785A and MIL-STD-470.

---

\* A description of the development of the TASA Development Model is given in Part I of this report. Part III of this report is a User's Manual that provides detailed information for use of the DEPEND computer program as part of TASA.

Inputs to the model should be identified by the contractor's program plan with inputs from the Air Force. The inputs include:

- (1) Identification of required functions for each phase of each mission
- (2) Definition of the various failure states of the system elements in the work breakdown structure.
- (3) Known or estimated values of reliability of system elements. (Estimates may be made through roll up of reliability test or MIL-HDBK-217 piece-part data through the work breakdown structure using the TASA model.)
- (4) Known or estimated values of maintainability. (Estimated or predicted values for maintainability at the subassembly level may be derived by methods defined in MIL-HDBK-472 and rolled up using the TASA model).

The contractor's R/M plan should show the plan for use of the TASA Dependability Model to perform failure mode and effect analysis. In addition the model should be used to identify reliability critical items and their effect on system reliability and maintainability. Results of the analysis should be used to evaluate proposed design changes for their effects on system reliability and maintainability.

#### R/M Test Program Plan

A major portion of the R/M program plan should be devoted to the R/M test design. Although the burden of formulating the detailed R/M test design may be delegated to the equipment contractor, the Air Force must supply direction to the effort. In particular the Air Force must define the system mission and must decide what mean time between failure and mean time to repair is acceptable and what confidence level it wishes from the test program.

#### R/M Prediction

The R/M plan should provide a strong mechanism for management visibility by including a requirement for showing reliability and maintainability growth throughout the entire development program. This mechanism should employ the Battelle developed TASA Dependability Model. An initial prediction of the reliability and maintainability of the system should be made with the model with the aid of MIL-Hdbk-217 piece part data and MIL-Hdbk-472 data for maintainability. A new prediction should be made each month and at any time a major design change is made during the entire development program and provided to the USAF in a specific, timely schedule. Each new prediction should utilize current data from tests or other sources as the data become available and the results should be compared to the initial prediction to show the R/M growth and to indicate whether or not the R/M goals are being met.

### Reliability Demonstration Test

A reliability demonstration test should be performed on a sample of at least two of each functional element making up the dual-frequency SATCOM system in accordance with MIL-STD-781B, Test Level F, using the alternative method of temperature cycling. The quantitative reliability requirement for each functional system element should be specified in MTBF and should be based on the apportionment of the reliability of the elements to achieve the total system reliability requirement. Accept/reject criteria should be that specified in MIL-STD-781 B, Test Plan IV.

### Burn-In Test

Each functional element of the dual-frequency SATCOM system should be subjected to a 50 hour failure free operational burn in before beginning the reliability demonstration test. In the event a relevant failure occurs during the burn-in period the test should be restarted at zero hours. In the event that pattern failures are observed proper corrective action in the form of design changes or reselection of parts should be made before the test is restarted.

### Test Environment

The test environment for both the burn-in and reliability demonstration tests should be that defined in Paragraph 5.2.3.2 of MIL-STD-781 B. Vibration should be applied to the test samples as required by Paragraph 5.3.2 of MIL-STD-781 B.

### Equipment Operation

The functional elements should be placed in operational modes during all phases of the test program with the operational modes being changed to exercise the equipment under various operational modes and at differing frequencies where applicable. Daily checks of performance parameters should be made to detect any failures that may occur. The test plan should define the various operational states for exercising the equipment during the tests.

The test plan should define countable operating hours. The reliability demonstration test duration should be defined in countable unit operating hours and should run for a minimum of two times the MTBF for the functional element under test.

### Test Failures

Test failures should be categorized according to Paragraph 5.5.1 of MIL-STD-781 B. The test plan should provide for written failure reports and procedures for analysis and review of failures. These failure reports and the results

of any analyses along with proposed corrective action should be made available to the Air Force on a timely basis. Failure definitions should be defined with mutual agreement with the USAF prior to initiating tests (see section on Procuring Agency R/M Information Requirements, Items 6 and 7).

#### Maintainability Demonstration Test

The maintainability demonstration test should be performed in accordance with MIL-STD-471 A, Test Method 1, Test B. The test plan should provide for testing each of the functional elements of the dual-frequency SATCOM system. The plan should define the quantitative values for the desired specified down time, the maximum tolerable downtime, the producers risk, and the consumers risk for each of the functional elements of the system.

The test plan should describe the maintenance concept along with fault isolation methods. The test design should be formulated to demonstrate this maintenance concept in an environment similar to that expected with the actual use of the equipment. The test plan should include a list of typical faults to be encountered in the equipment. This list should be prepared by the equipment contractor. The number of faults to be included in each demonstration test should be determined in accordance with the requirements of MIL-STD-471 A.

The test plan should define the responsibilities of both the Air Force and the equipment contractor. The responsibilities of the Air Force should include:

- (1) Selection of faults by random drawing from list prepared by the contractor
- (2) Witnessing all facets of the maintainability demonstration test
- (3) Approving all data sheets
- (4) Reviewing all test results and calculations

The contractor should be held responsible for:

- (1) Preparing the master list of faults to be included in the equipment.
- (2) Setting up the fault simulation in the equipment under test.
- (3) Complete performance of the demonstration test (preparation, malfunction verification, fault isolation, corrective action, and verification of corrective action)
- (4) Performance of required calculations
- (5) Reporting of test results
- (6) Selection and training of testtechnicians
- (7) Provide data sheets previously approved by the Air Force

The test plan should include the organizational structure of the test team and should describe the functions of each member.

## **R/M Management and Control**

The R/M program plan should define the management structure and methods to maintain control of the R/M effort. This portion of the plan should identify, through organizational charts, all key organizational elements and the personnel responsible for management of the R/M program and how they relate to the organizational structure of the contractors and the procuring agency's total organization.

## **R/M Program Management**

The contractor management structure should incorporate a program office with direct line responsibility to upper levels of company management for the dual-frequency SATCOM system development program. The program office should have a director or manager who has prime responsibility for the development program and serves as a counterpart to the Air Force Program Manager. The organizational layer beneath the Program Manager should be comprised of Project Engineers for each of the program functions such as design, manufacturing, quality assurance, maintainability, reliability, etc. This management should place the reliability and maintainability functions at a level of authority equal to engineering, manufacturing, and quality assurance to assure that the authority exists to properly implement the R/M program. The organizational structure should also define the lines of authority between service elements such as purchasing, contracting, component engineering, etc. to assure that the R/M Project Engineers have proper voice in parts procurement, incoming inspection, etc. The organizational structures should make provision for membership of review and control boards which should be comprised of members from both the Air Force and the contractors.

A design review board should be established to conduct at least production readiness reviews, preliminary design reviews, functional configuration audits, critical design reviews and a physical configuration audit as needed to insure corrective action on quality, reliability, and safety related problems.

A parts control board should be established to:

- (1) Enhance the reliability and commonality of parts.
- (2) Maintain standardization procedures and controls.
- (3) Coordinate requests for approval of nonstandard parts.
- (4) Review part failure rates.
- (5) Coordinate technical procedures of a parts reliability program.
- (6) Prepare parts utilization criteria.
- (7) Evaluate parts supplier survey reports.
- (8) Disseminate parts information to users.
- (9) Report inadequacies of MIL parts and MIL parts specifications.

The membership of the parts review board should include representatives from at least the component engineering, reliability, engineering, design engineering, quality engineering, the USAF, and possibly subcontractor representatives if applicable.

#### R/M Program Control

The R/M program plan should define the methods by which control of the program is to be maintained. This plan should provide mechanisms for maintaining a high degree of management visibility throughout the dual-frequency SATCOM system program. The mechanisms should include those designed to yield a high degree of interchange of information between the Air Force Program Manager and the contractor management organizations. Mechanisms must be provided to exercise R/M control over all subcontractors and vendors associated with the program. The R/M control scheme should provide for problem identification, corrective action, monitoring, assessing, and reporting of the program status, and taking appropriate action to assure that the R/M goals are being met and the program is on schedule. The R/M plan should provide for appropriate checks and controls for identification, control and handling of critical parts, components, subsystems, and engineering change proposals from the design stages through final acceptance of the system.

#### Program Review

The R/M program plan should require monthly program review meetings throughout the entire program. These reviews should be utilized to provide the Program Manager a briefing of the accomplishments, current status, and future schedule of the various tasks on the program. The program reviews should provide the Program Manager insight as to whether or not R/M goals are being met and whether or not the contractors are meeting their scheduled milestones. The program reviews also provide a mechanism for identification of problem areas and discussion of solutions.

#### Status Reports

The R/M program plan should require monthly status reports. These reports should provide documentation of the program progress in essentially the same areas as the program review meetings. The reports should include the updated R/M predictions. The main value of the status report is to provide documentation of the program history.

#### Design Reviews

The R/M program plan should include provisions for several design reviews for each system element comprising the dual-frequency SATCOM system and design reviews for system integration. The design reviews should start with initial design concepts and continue throughout the design effort into production.

The first design review should be the concept review and should occur after the design definition has been completed but before detailed designs have begun. A second design review should be conducted upon completion of the electronics design of each function but before its release to drafting. This review is conducted to ensure that the electronics meets all specified functional requirements. The next review should be a mechanical design review and should be conducted when the mechanical layouts are complete but before the layouts are detailed. During this review such items as thermal analyses, test point location, and ease of access for maintenance as well as function of mechanical elements should be considered. Another design review should be conducted for each of the system elements when the mechanical and electronic design has been finalized and scheduled to be released for manufacturing. A final design review should be made for system integration to assure that all elements of the system are compatible. Provision should be made to permit special design reviews to be conducted at any time during the design or production to resolve any unexpected or major problems that cannot be solved in the normal routine.

In addition to the equipment design reviews, a test plan review should be conducted when the test equipment is finalized and prior to the completion of the detailed test procedures. This review should be utilized to make sure that all test requirements will be adequately covered.

#### Reliability/Maintainability Monitoring

The Air Force R/M program plan should make provision for a resident monitor to observe at least the equipment qualification tests and R/M demonstration tests. The monitor can be provided through independent contractors, the Air Force, or other government agencies. The function of the monitor should be to witness the conduct of the tests to assure the Air Force that the program is being conducted as specified and to provide a communication link between the Air Force and the contractor. The monitor can provide information to the Program Manager and his staff concerning any problems as they develop and can provide information concerning the critical tasks in the program.

#### R/M Data Records

The R/M program plan should define the data to be supplied to the Air Force by the contractor. These data should include results from parts tests, breadboard tests, circuit analyses, quality control inspections, qualification tests, reliability demonstration tests, and maintainability demonstration tests. The data records should include failure reports, vendor test results, engineering change proposals, engineering change notices, R/M predictions, corrective action reports, etc. The data records should be supplied in a timely manner so that the Program Manager can follow the day-to-day progress of the program.

### Program Scheduling

The R/M program plan should contain detailed schedules showing how the major phases of the program relate to each other. The schedules should include the times at which data and information is to be supplied to the Air Force. The schedules should be presented in the form of PERT and Gantt (milestone) charts, or some other acceptable form of chart that indicates lead time for all major items and tasks, and shows that all tasks fit into the overall program schedule. The schedule should show the times for delivery of all reports and should key design reviews, program reviews, R/M predictions, and test schedules to task progress. The program schedule should also show the estimated manloading for each of the R/M tasks on the program.

### **SECTION III**

### **CONCLUSIONS**

The foregoing plan guidelines and implied requirements have been designed to result in a comprehensive plan that integrates reliability and maintainability functions and requirements. Appropriate areas of applicable STDS have been covered. Since each plan is equipment and contractor dependent (e.g. the contractor management organization must be tailored to his own organization) specific details cannot be provided in a general purpose directive of this type. However, adherence to the requirements, steps, and details presented will yield a good, solid working plan which will provide the necessary technical requirements for the system, the methods for management and control of the R/M effort, and a specific, comprehensive test design.

Included in the plan requirements are the use of the TASA analysis approach for predicting reliability, availability, maintainability and dependability. Close adherence to these concepts and methodology coupled with timely updates and reports to the USAF will be an excellent mechanism for guiding the R/M growth of the equipment as well as provide a solid method of tracking program progress.